

Finite Element Implementation and Application of the DTF Model to the Assay Test

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Objective

- Implementation of the “Next Generation” HE Constitutive Model for Use in ESA-EA “Production Codes”.
 - A better micro-mechanical basis than the current production model (ViscoSCRAM).
 - Less Expensive than a GMOC approach.
- Assist in the Development and Assessment of the Model

Stress-Strain Law for the DTF Model

$$\bar{\sigma} = \frac{1}{\frac{\theta_b}{\kappa_b} + \frac{\theta_p}{\kappa_p}} tr(\bar{\varepsilon})I + \frac{2}{\frac{\theta_b}{\mu_b} + \frac{\theta_p}{\mu_p}} \left[\bar{\varepsilon} - \frac{1}{3} tr(\bar{\varepsilon})I \right]$$

Where,

θ_b

is the volume fraction of the binder

θ_p

is the volume fraction of the HMX particle

κ

is the bulk modulus

μ

is the shear modulus

}

With subscripts p and b as appropriate.

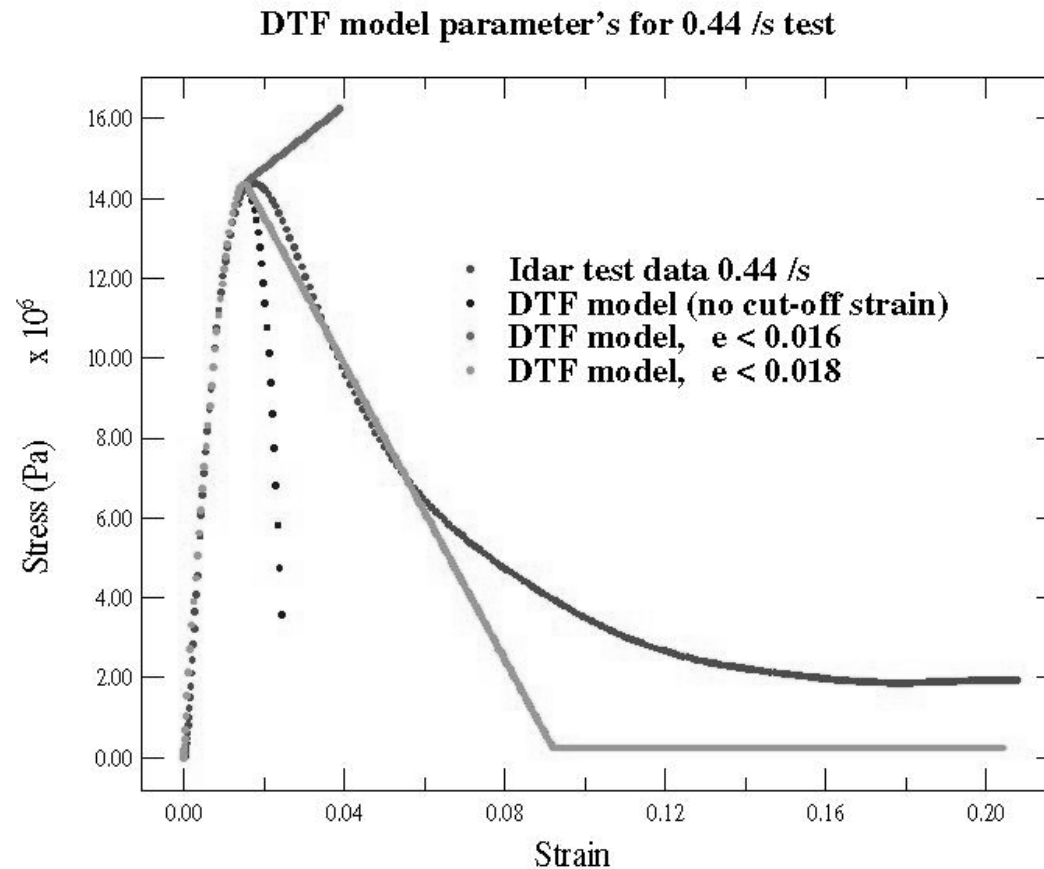
Implementation

- Explicit
 - Incremental stress and stress update over each time step for each finite element.
- Implicit
 - Incremental stress and stress update over each time step for each finite element.
 - Form the Jacobian Tangent Stiffness for each element for global assembly.

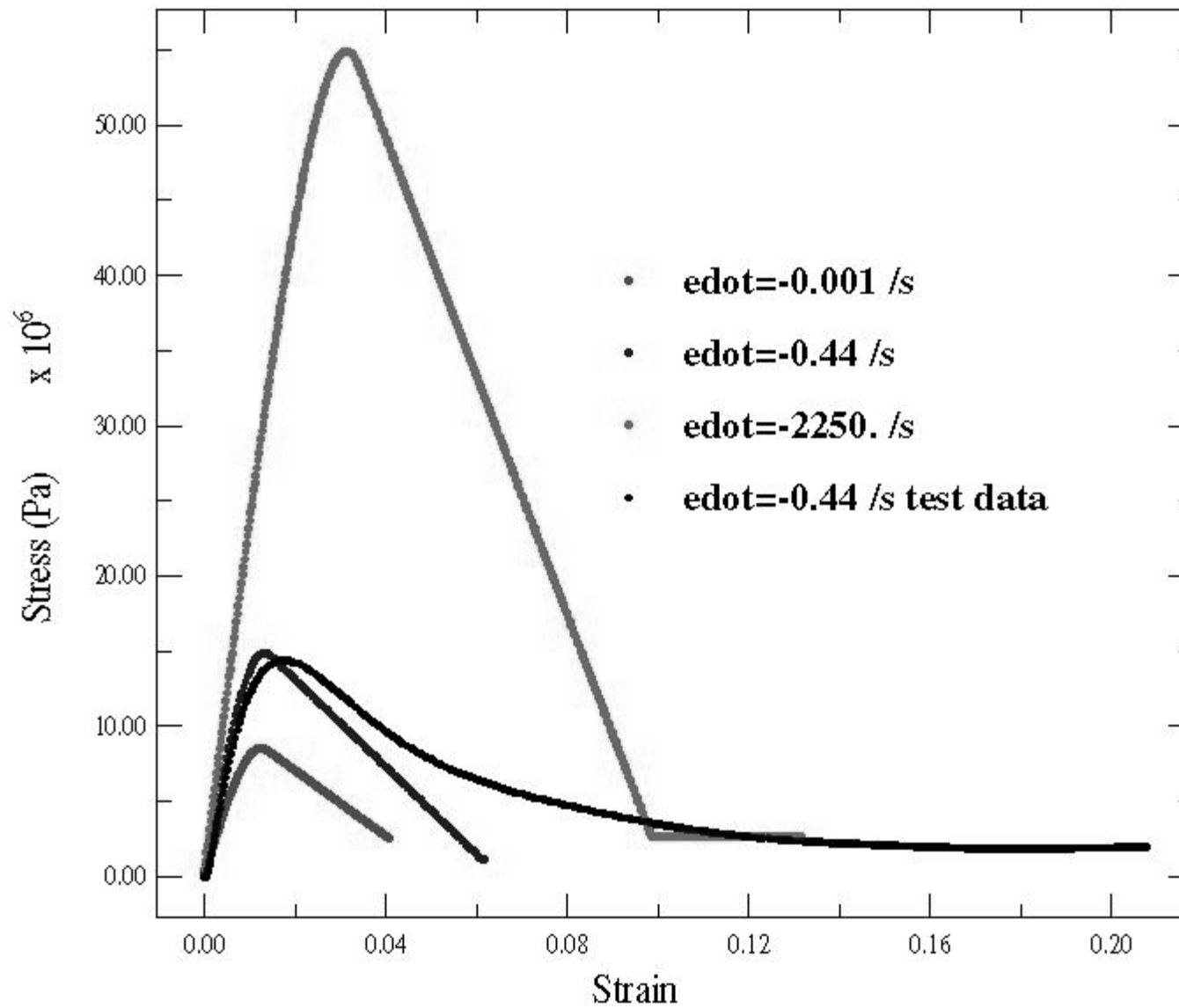
Strain Rate Dependence

- Addition to Current DTF Model to assess Rate Effects
- Rough Phenomenological fit of DTF Parameters to Low, Medium and High Rate Test Data

DTF Rate-Dependent Fitting Sequence Using Low-Rate Test Data and the Implicit Version



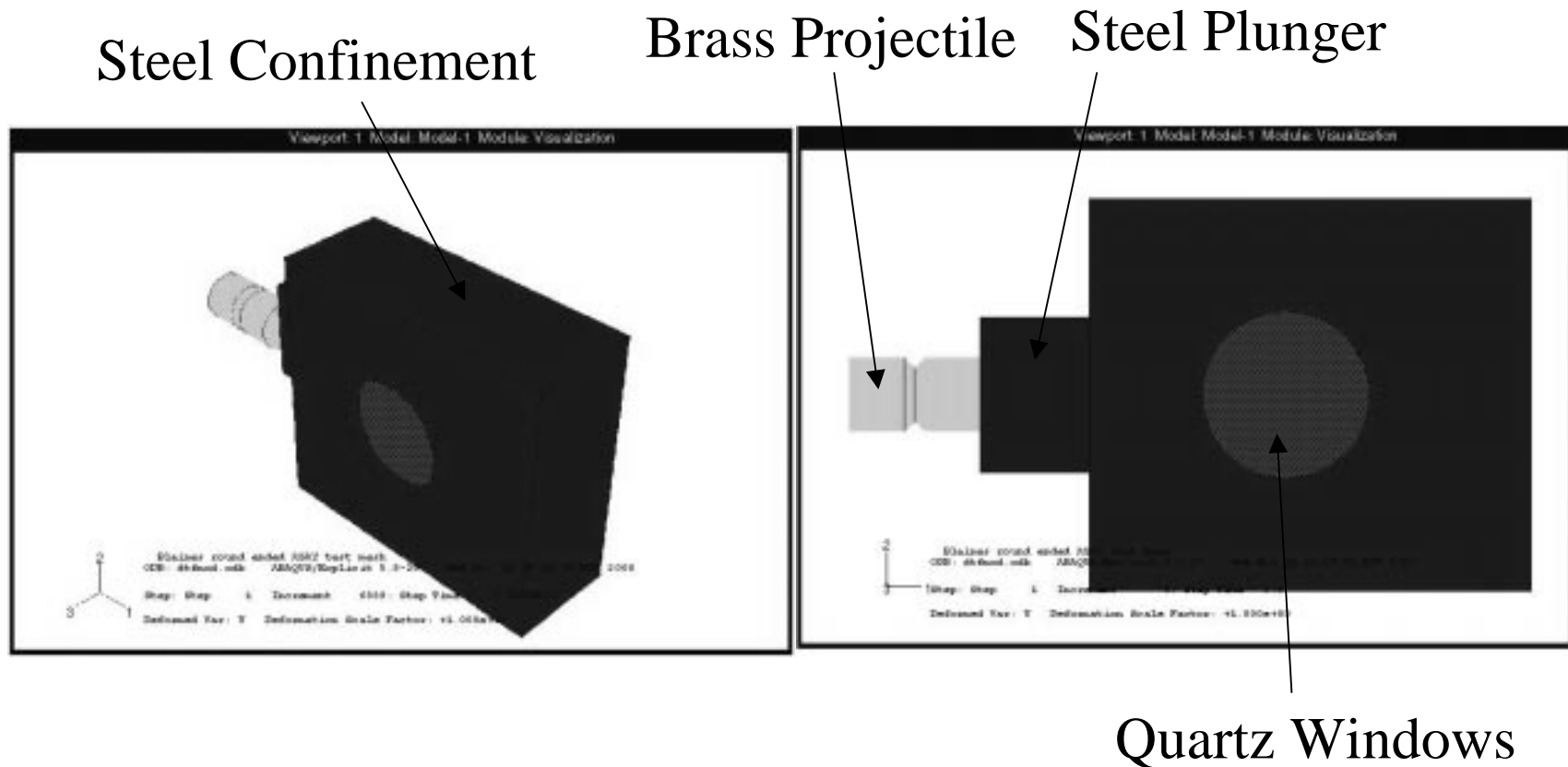
DTF Model Rate Dependent Fits as Implemented



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ASAY TEST - 10 mm Round Ended Plunger



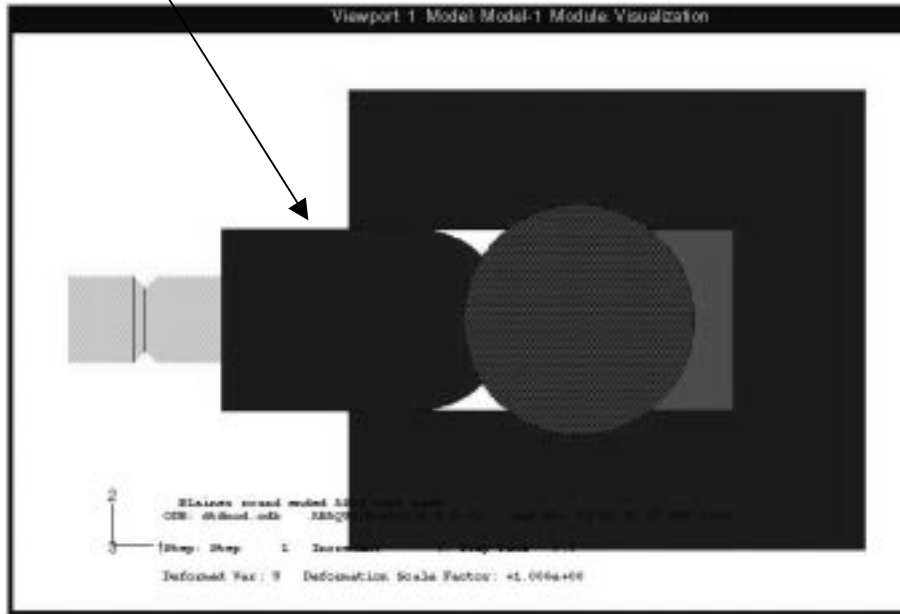
~ 50,000 elements and nodes in this model

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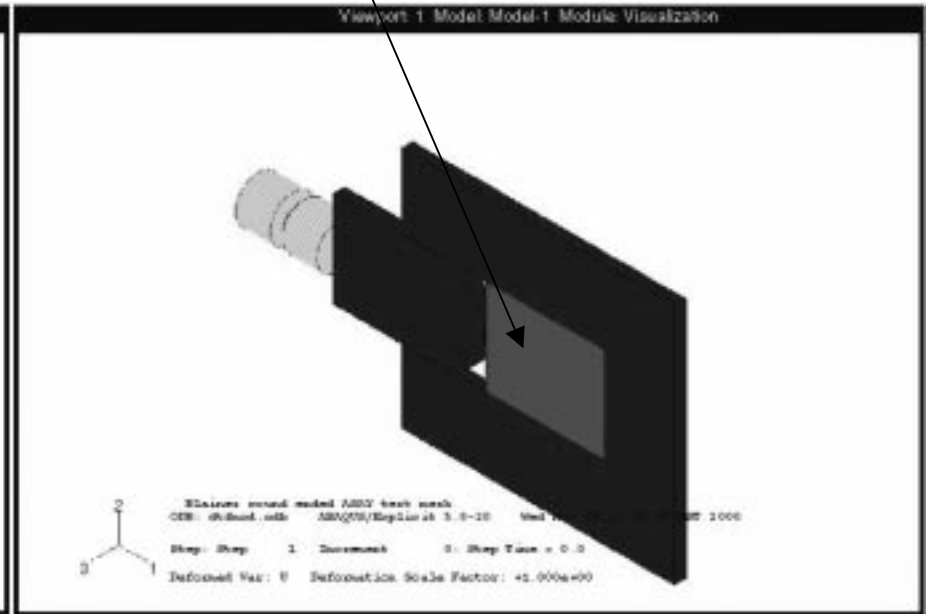
ASAY TEST - 10 mm Round Ended Plunger Model

10 mm steel plunger



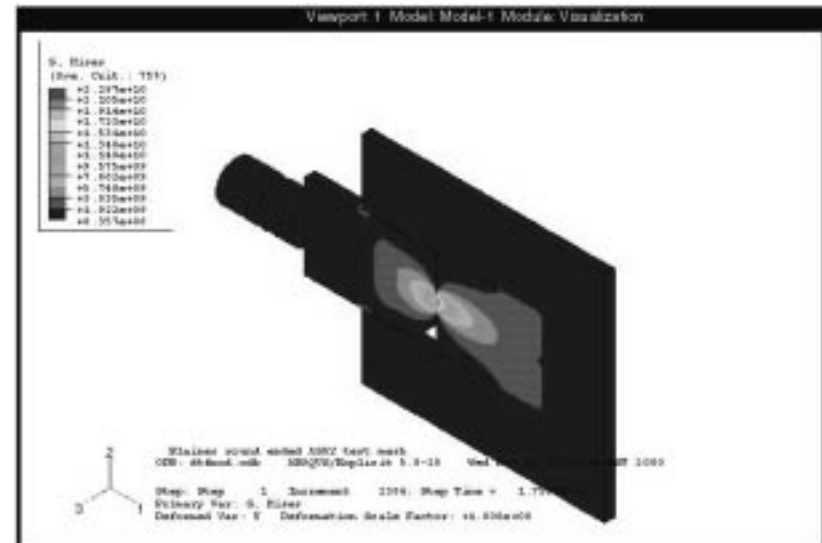
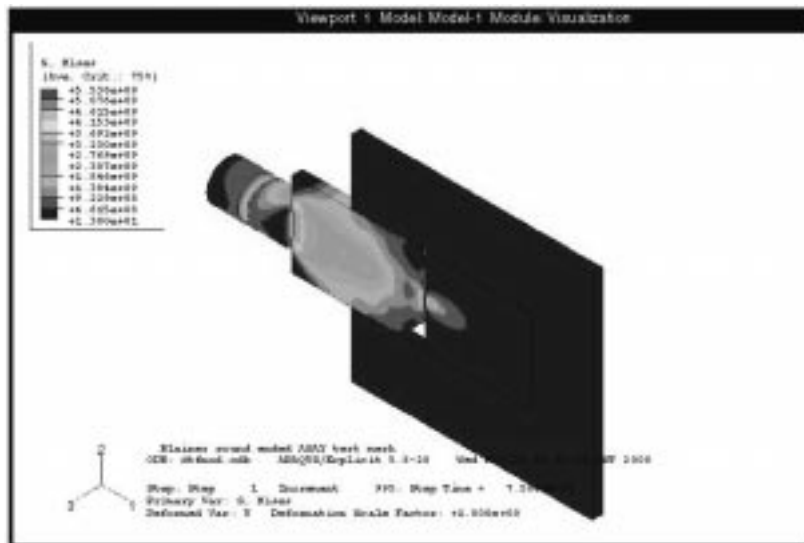
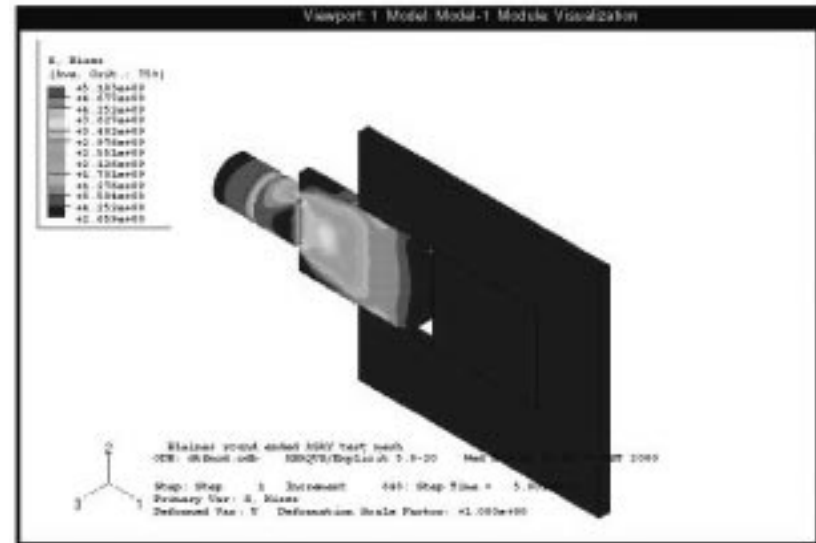
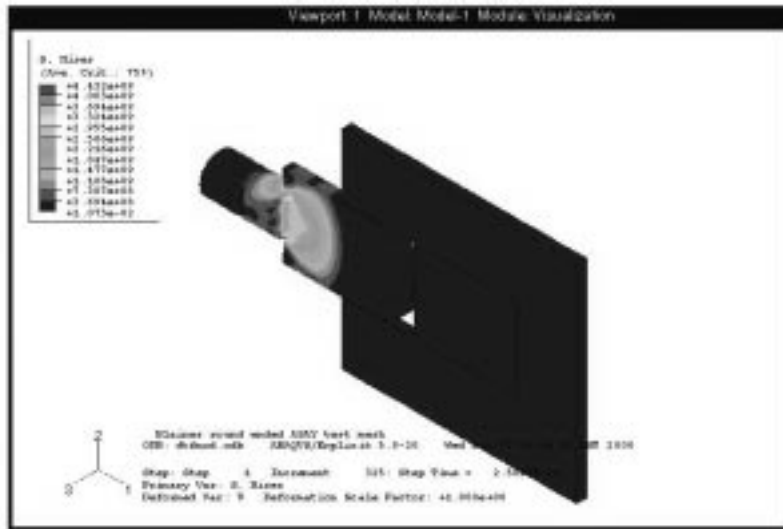
View with steel confinement removed.

PBX 9501 Material

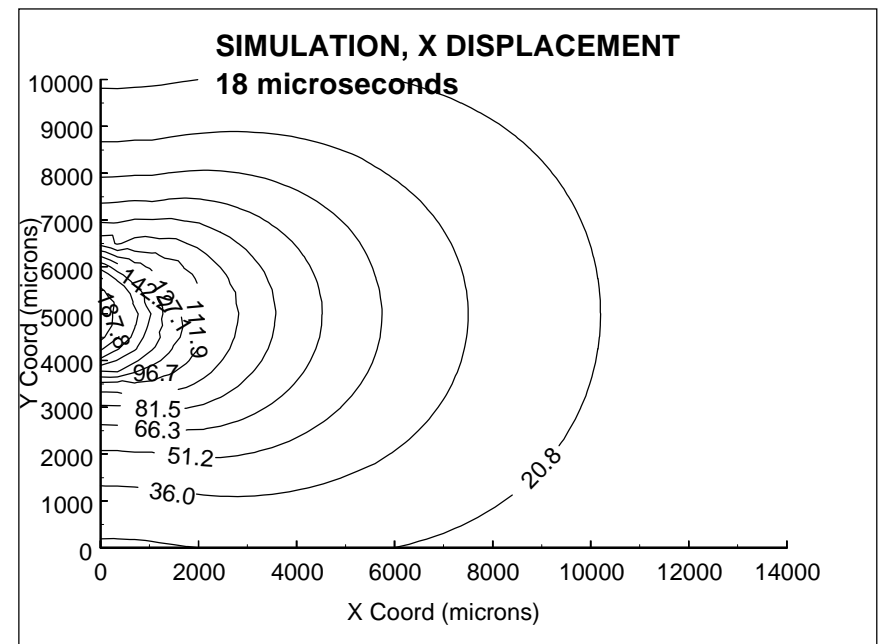
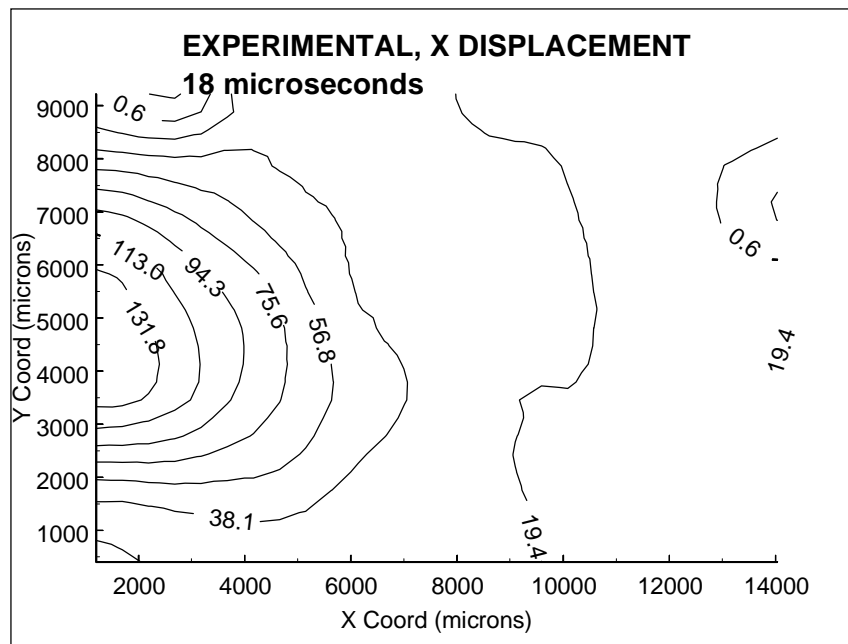


View with steel confinement and windows removed.

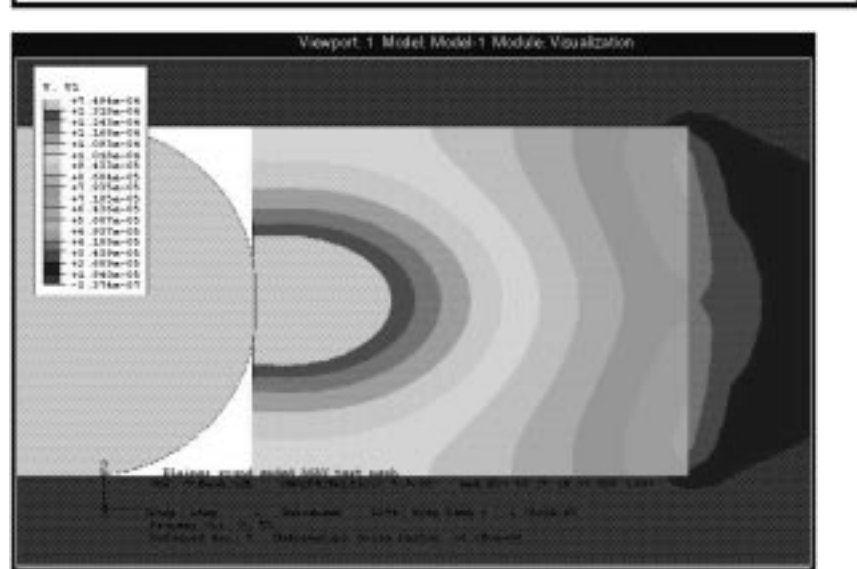
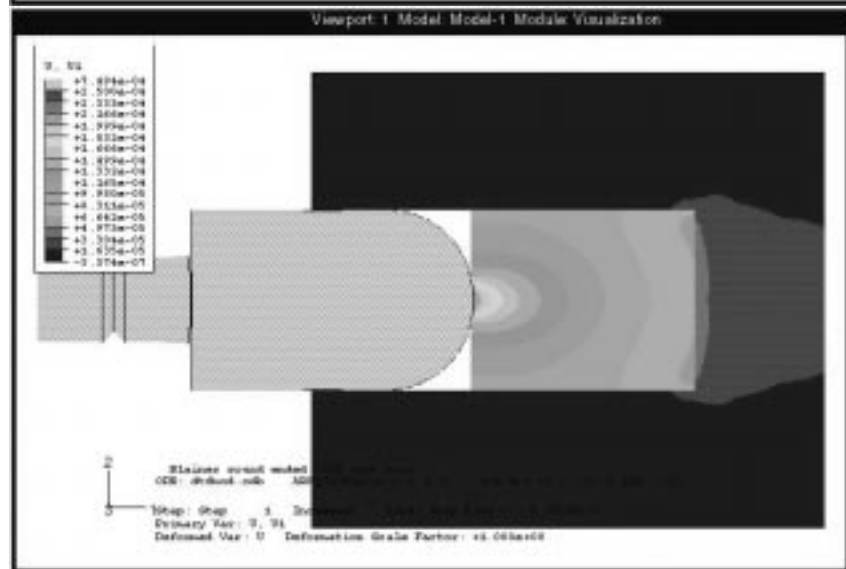
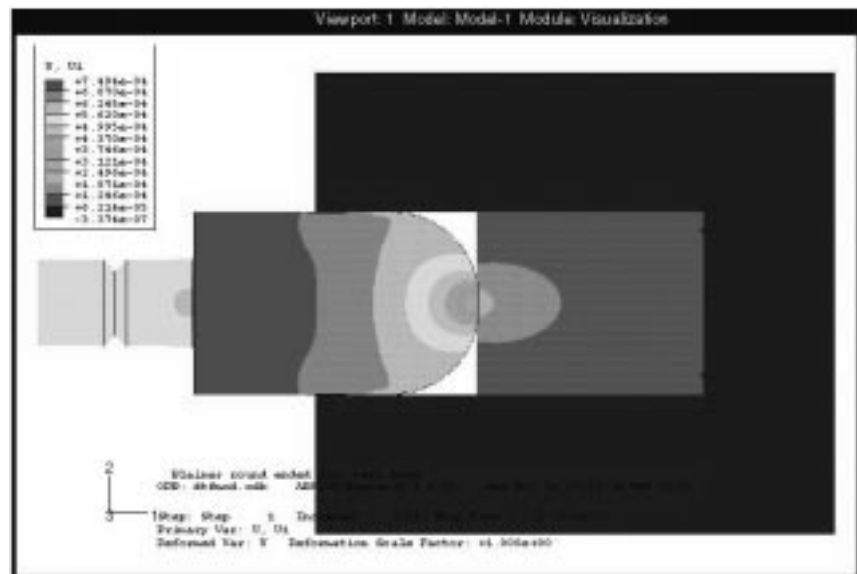
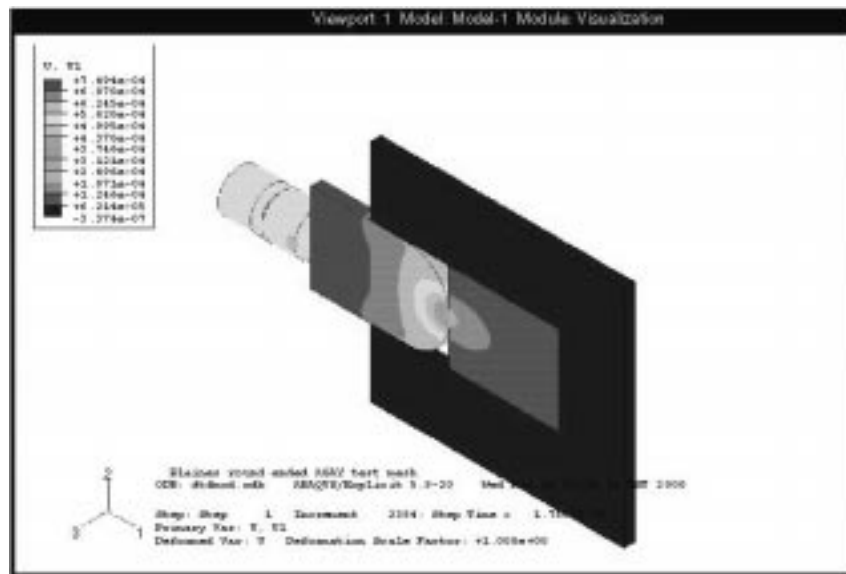
Stress Wave Sequence - Projectile Velocity 185 m/s



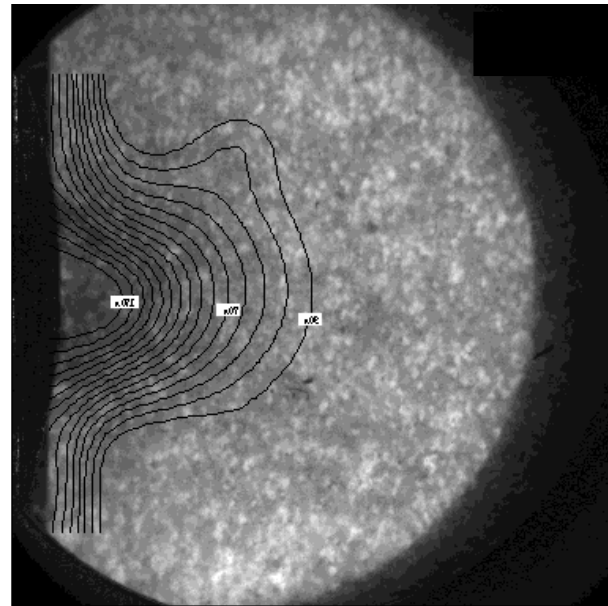
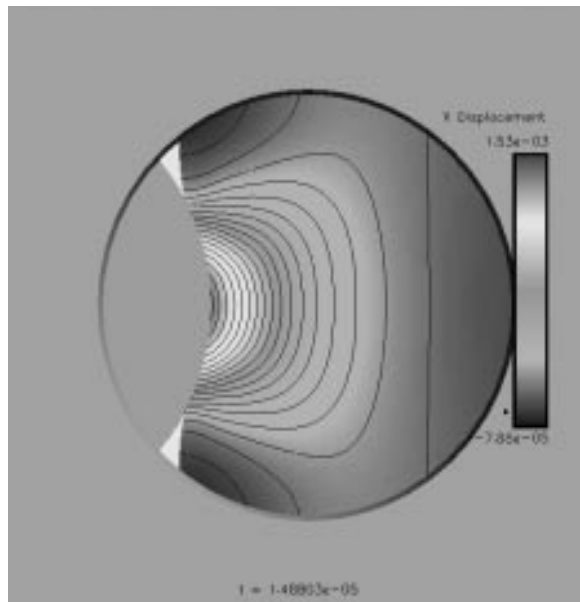
ViscoSCRAM Comparison with Test Data



Sequence of Displacement Contour Development with the Final Frame Having Limits of the Experimental Values Applied

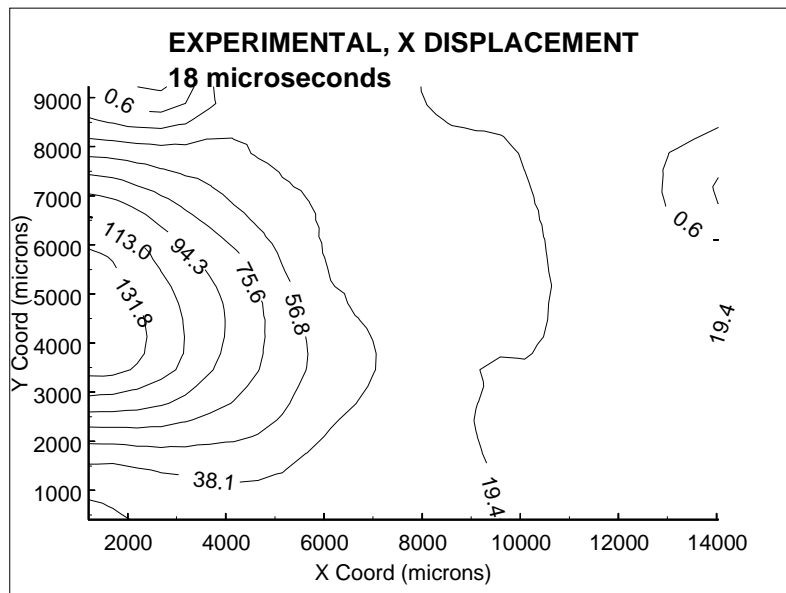


ViscoSCRAM Qualitative Contour Comparison as Viewed “Through the Window”

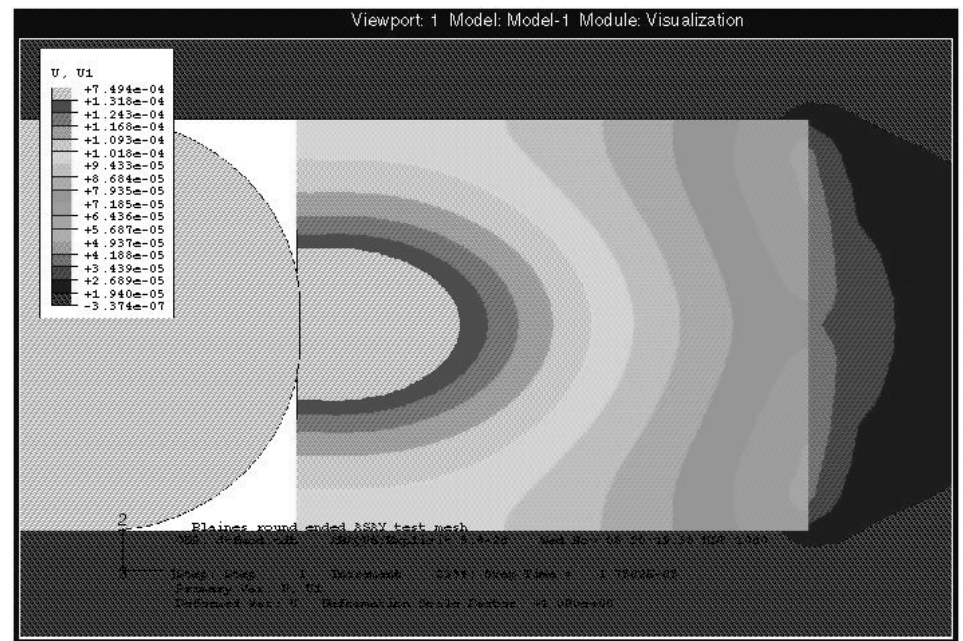


ASAY Test Modeled with DTF Model using Initial Parameters That Were Derived to Fit the Jerry Dick Flyer Plate Data

Experimental contours at 18 micro-seconds

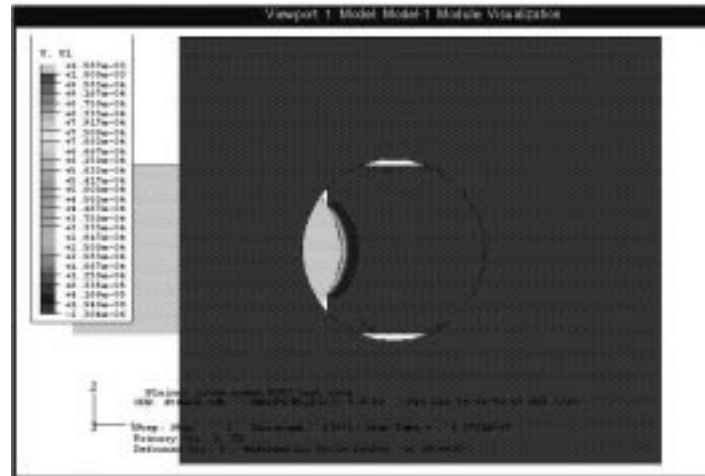
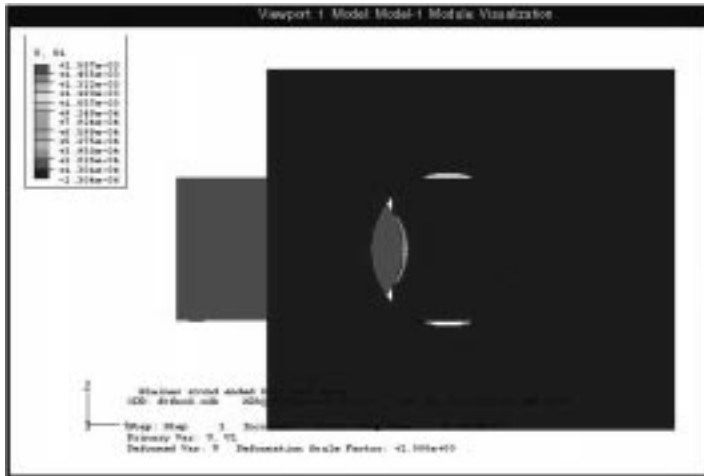


Corresponding Contour limits at 17 micro-seconds from calc.

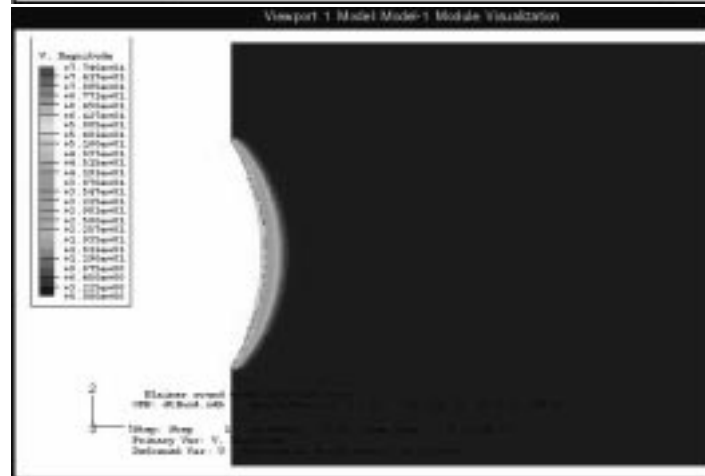


Conclusions: (1) Model is too stiff with initial parameters
(2) Material Rate Dependence is Needed

ASAY Test Modeled with DTF Model Using the Rate-dependent Fits as Implemented



Conclusion:
With these parameters
the model is too soft!



Conclusions

- A Physically Based Strain Rate Dependence Needs to be Added to the Model.
- The DTF Model is Showing Promise in Simulating Available Experimental Results.
- Computationally Cheaper Than both ViscoSCRAM and the GMOC Models.
- This Development is Work “In Progress”.